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Nutritional understanding among elite, competitive, male cyclists

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NUTRITIONAL UNDERSTANDING AMONG ELITE, COMPETITIVE, MALE CYCLISTS

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ABSTRACT

NUTRITIONAL UNDERSTANDING AMONG ELITE, COMPETITIVE, MALE CYCLISTS

By Leslie S. Funk

This study investigated nutritional understanding among elite, competitive, male cyclists. A survey was utilized to measure nutritional understanding of the participants and to determine the top three sources of nutrition information relied upon by the cyclists. The sample included category 1, 2, and 3 cyclists who elected to complete the survey (N= 41). No statistically significant differences between median nutrition scores were identified; the median score for the total group was 55% correct. A moderate correlation was identified between racing category and the level of nutrition information source selected. The group scored poorly on questions pertaining to hydration, nutrition for training and recovery, pre and post competition carbohydrate intake, and macronutrient percentages of daily caloric intake. Nutrition intervention is recommended to address areas of low knowledge and understanding, and develop practical skills for assessment of individual energy expenditure and dietary intake.

DEDICATION

This thesis is dedicated to my loving husband Chris. His love, support, and encouragement made my dream of achieving a Master's degree a reality. Additionally, I am thankful for the love and understanding of my children, who patiently let me work on my 'homework" for many hours.

I thank Dr. Bethany Shifflett for being the best mentor ever! I have learned so much from her in my roles as both student and teaching assistant. The experience of this thesis has been fulfilling and challenging, thanks to her guidance, expertise, and support.

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CHAPTER 1

This chapter is divided into the following sections: background for the study, statement of purpose, statement of hypotheses, delimitations, limitations, assumptions, definition of terms, and summary.

Background for the Study

Nutritional status affects all athletes, yet the effects are not always felt in the short term. Dietary practices such as chronic caloric restriction, and calcium, iron, and zinc deficiencies may take years to affect an athlete's performance in sports such as gymnastics or wrestling. In contrast, endurance athletes may feel and observe immediate effects related to dietary intake. As a group, endurance athletes have higher energy expenditures than other types of athletes, such as sprinters, weight lifters, and gymnasts. Carbohydrate and fluid intakes are crucial to perform at an optimal level in an endurance sport; slight declines in hydration status or glycogen levels can have immediate and disastrous effects on performance during competition (Lamb, 1995).

Elite, competitive cyclists, as a subgroup of endurance athletes, have the highest energy expenditures in both training and racing (van Erp-Baart, Saris, Blinkhorst, Vos, & Elvers, 1989). The highest energy expenditures are found during stage races, such as the Tour de France, consisting of multiple days of high intensity cycling for 5-7 hours per day. Second to stage races in caloric expenditure are road racing events that take place in one day and last for many hours. In both stage racing and road racing situations, hydration status and glycogen stores are crucial to a rider's ability to sustain the aerobic energy output required to compete at the elite level (Lamb, 1995).

Probable sources of nutrition information for elite cyclists include the coach, a sports nutritionist, teammates, academic journals, web sites, family, magazines, college nutrition/health courses, and registered dieticians. The accuracy of information may vary, as well as the intent of the information source. For example, an Internet search (google.com search engine) for web sites pertaining to "cycling and nutrition" found multiple web sites that appear to offer nutritional information to cyclists, yet are actually selling supplements and ergogenic aids. Types of web sites include coaching services, such as Asimba.com, which states, "Without the right fuel, your training will lose effectiveness. Feed your body well," followed by a recommendation for cyclists to "check out their diet and supplement it to improve performance." Asimba coaching provides a link to Personal Best Nutrition (PBN), a website that appears to provide sport-specific nutrition information. Clicking on the "cyclists" tab at Personal Best Nutrition provides an "article" (no author or references provided) containing a "sports nutrition program suitable for a competitive road cyclist." The program recommends supplemental carbohydrate beverages during training, supplemental protein during periods of intense training, creatine supplementation to enhance performance during important races, multi-vitamin and antioxidant supplements designed for endurance athletes, phosphate loading, 2nd Wind Athletic Accelerator (a product that claims to reduce lactic acid and HMB (beta-hydroxy- beta-methylbutyrate). HMB is a supplement promoted to decrease protein breakdown during heavy training (Slater & Jenkins, 2000).

Following lengthy supplement recommendations, Personal Best Nutrition mentions a unique product of their own, called "PBN Ultimate Performance Accelerator capsules," that provides HMB and other nutrients so that "you are not taking lots of different pills." The entire site fails to provide nutritional information relevant to what foods to eat, meal timing, hydration and proper fueling for training or racing.

An Internet search using Bikecrawler.com, a cycling-based search engine, to find "nutrition information" produced four sites, all of which sold nutritional supplements and ergogenic aids for cyclists. One of the sites, Botanica-bioscience.com, sells "2nd Wind X-celerator," a product that claims to improve recovery from training and racing by increasing lactic acid clearance and metabolism two-fold, both during and after exercise. Although the company mentions a clinical study conducted to evaluate the effects of the product, such a study was not found during the review of literature for this research. A second search on www.bikecrawler.com, "road racing and nutrition," located one site that promoted a low carbohydrate (40%), high protein (30%) diet for cyclists (roadracing@mylongisland.com). It is interesting to note that although this web site was not selling supplements or coaching, it was the only site that came up when searching under the theme of "road racing and nutrition."

Websites of cycling teams and clubs provide articles on nutrition and links to nutrition-related information. For example, the cycling club website (The Greensville Spinners) offered a "groundbreaking" article that recommended "not just extra protein to improve performance, but honey is proven to increase endurance," illustrating the tendency for nutritional advice to lack depth and tend toward supplementation. This tendency may be partly due to convenience; it is relatively simple to try eating some honey before a workout compared to analyzing daily dietary intake. Additionally, the hope that a supplement or a specific food can actually increase one's speed and strength may drive the interest in such products and theories that continue to surface.

For cyclists to discern truthful nutrition information from advertising claims, a good understanding and strong knowledge base in nutrition is necessary. To date, the level of nutritional understanding and knowledge in elite cyclists has not been investigated. Cyclists are exposed to marketing in magazines, at races, and on the Internet that promises world-class performance with the use of a drink, pill, gel, or bar, coupled with a photo of a legendary cycling athlete utilizing the product. For example, The Saturn Cycling Team web site shows pictures of their top riders "slamming down Revenge," a carbohydrate replacement beverage produced by Champion Nutrition, a company that co-sponsors the team. Thomas and Quindry (1997) recommended assuming an approach that every marketing claim is false unless proven by peer-reviewed research. They advised consumers being aware of common marketing techniques used in advertising that promote supplements, diets, and fitness fads. The list of marketing techniques includes: celebrity endorsements, testimonials, and foreign research studies proving the product to be effective (Thomas & Quindry, 1997).

In this study, "elite" will be defined as cyclists that have achieved a ranking of category 3 or above, including professionals. The category system ranks cyclists based on racing experience and "placings" (finishing the race in top 10 positions) in qualifying races. The highest level is category 1, descending chronologically to category 5.

Category 3 represents riders who have a minimum of 25 qualifying races and accumulate 15 points during a 12-month period. For category 4 and 5 riders, points are awarded based on placing in1st to 6th place: 7 points for 1st down to 1 point for a 6th place finish. In category 3 and above, points are awarded for 10th place and above in road races, and 20th place and above in stage races. Category 1 riders represent the highest level of amateur riders and, if under contract riders become "professional" cyclists (United States Cycling Federation, 2001). This study will classify professionals with category 1 riders.

Statement of Purpose

The purpose of this study was to investigate the level of nutritional understanding and knowledge among elite, competitive, male cyclists, specifically category 1, 2, and 3 riders. Although dietary intake and eating patterns of elite cyclists have been quantified by previous research (Garcia-Roves, Terrados, Fernandez, & Patterson, 2000; Jensen, Zaltas, & Whittam, 1992), the nutrition understanding and knowledge of the athletes was not investigated. In an article "Dietary Intake and Nutritional Practices of Elite Athletes," Burke (1991) confirmed the need for research that investigates the nutrition practices of athletes and draws conclusions relating to the effects of diet on performance. He suggested collecting information about training and competition, anthropometric data, nutrition beliefs, sources of nutrition information, daily energy intakes, precompetition nutritional behaviors, and the use of supplements for each type of athlete. For example, wrestlers and runners may have different, yet appropriate, responses to a survey of nutritional information. A wrestler's primary nutrition goals relate to weight loss, while a runner focuses on maximizing glycogen stores in the body. At this time, knowledge and understanding of nutrition principles relative to competitive cycling have not been studied specifically. Sources of nutrition information used by elite cyclists are an additional area for investigation. Previous findings regarding the adequacy of endurance athletes' diets demonstrate sub optimal energy and carbohydrate intake, as well as a possible lack of ability to achieve an optimal dietary intake without specific nutrition education (Tanaka, Tanaka & Landis, 1995).

Research Hypotheses

1. The mean level of nutrition understanding and knowledge will be highest in category 1 cyclists, descending by racing category, with category 3 riders demonstrating lower mean levels of understanding and knowledge.
2. Category 1 riders will select high-level nutrition information sources more often than category 2 or 3 cyclists.

Null Hypotheses

1. There will be no statistically significant differences in the mean level of nutrition understanding and knowledge among category 1, 2, and 3 male cyclists.
2. There will be no statistically significant differences in the mean level of nutrition understanding and knowledge among male cyclists grouped by years of experience.

Delimitations

This study is delimited to the following:

1. The participant pool surveyed consisted of adult male, United States road cyclists who compete in category 1, 2, or 3 as members of the United States Cycling Federation or as part of an NCAA collegiate team. Only responses from male cyclists were used.
2. The age range corresponded to the ages of the participants, with a lower limit of 18 years.

<u>Limitations</u>

Limitations inherent in this study included the following:

1. The measure of nutrition knowledge was limited by the content of the survey items.
2. The survey instrument was multiple-choice, limiting the participants, ability to express additional knowledge regarding nutrition.

<u>Assumptions</u>

The following were the assumptions of this study:

1. Participants completed the survey based on their own knowledge of nutrition.
2. Participants understood how to complete the survey.
3. The survey produced reliable data.

<u>Definition of Terms</u>

<u>Body Mass Index (BMI)</u>: A computation using body mass and stature to evaluate body weight (McArdle, Katch, & Katch, 1996).

<u>Cadence</u>: Revolutions of the pedal crank per minute while cycling (Faria, 1978).

Ergogenic aids: The application of a nutritional, physical, mechanical, psychological, or pharmacological procedure or aid to improve physical work capacity or athletic performance (McArdle et al., 1996).

Obesity: Defined by the Surgeon General as having a BMI ≥ 30 (McArdle et al., 1996).

Overweight: Defined by the Surgeon General as having a BMI ≥ 25 (McArdle et al., 1996).

Power (watts): The time-rate of doing work, a computation using force, distance, and time. (McArdle et al.,1996).

Road races: Single-day, variable distance and terrain, competitive cycling events (United States Cycling Federation, 2001).

Stage races: Multi-day, variable distance and terrain, competitive cycling events (United States Cycling Federation, 2001).

UCI: The International Cycling Union which governs all aspects of cycling.

USA Cycling: Colorado-based governing body of competitive cycling in the United States.

USCF: United States Cycling Federation, the member association for competitive road and track cyclists, responsible for categorizing riders and issuing racing licenses.

Summary

This chapter included the background for this study, which indicated a need for investigating the level of nutrition understanding and knowledge among elite, competitive cyclists. The purpose of this study was to examine the level of nutritional understanding and knowledge present in a group of elite, competitive, male cyclists. Two hypotheses were stated: the first stated that there would be no statistically significant difference in the mean level of nutrition understanding and knowledge among category 1, 2, and 3 riders. The second hypothesis stated that there would be no relationship between racing category level and the sources of nutrition information utilized. Delimitations, limitations, assumptions, and definitions of terms were listed.

CHAPTER II

Review of the Literature

Nutrition is important for all humans, from the average American to the elite, competitive athlete. Endurance athletes have specific nutrition needs related to a high training volume leading to a substantial increase in energy expenditure. Elite, competitive cyclists represent a group of endurance athletes with perhaps the highest energy expenditure among athletes, particularly in events such as the Tour de France and other stage race events. Elite athletes may understand that nutrition is important, possibly critical to training and performance, but do they have sufficient nutritional knowledge and understanding to achieve optimal dietary intake?

This review of literature examines the influence of nutrition in the general population and the nutritional needs of endurance athletes. Research that evaluates the nutritional practices of endurance athletes will be examined closely in relation to the level of nutritional understanding present in athletes. Finally, the specific nutritional needs of elite, competitive, male cyclists will be discussed, as well as the effects of nutrition on performance.

Nutrition and the General Population

The role of nutrition in achieving and maintaining optimal health throughout the lifespan is well documented. The American Dietetics Association (ADA) position on the role of nutrition in health promotion and disease prevention programs states that nutrition plays a well-established role in the reduction of low birth weight infants, diabetes mellitus, and cardiovascular disease, as well as the prevention and control of some cancers (ADA, 1998). Additionally, the ADA states that risks of chronic disease and medical costs can be reduced with optimal nutrition and physical activity. In fact, 50% of chronic disease mortality is directly attributed to changeable lifestyle factors such as smoking, nutrition, and physical activity (ADA, 1998).

The prevalence of obesity in the United States continues to increase each year and currently, more than half of American adults are overweight (54.9% with BMI $\geq$ 25) and nearly a fourth (22.3% with BMI $\geq$ 30) are obese (National Institutes of Health, 2000). The health risks and chronic disease states associated with obesity include coronary heart disease, hypertension, dyslipidemias, gallstones, sleep apnea, osteoarthritis, and cancers of the reproductive organs. The number one cause of death in the United States continues to be coronary heart disease, and the second highest cause of death is obesity-related medical conditions (ADA, 1997). The ADA's position on nutrition education for the public to combat obesity states that consumer knowledge, attitudes, and behaviors regarding nutrition and food need to be objectively studied, and followed by implementation of appropriate education programs.

Nutrition and Endurance Athletes

Compared to the general population, endurance athletes exhibit behaviors that are considered beneficial to achieving optimal health. A high level of physical activity coupled with the maintenance of an ideal body weight and body composition are recommended by the American College of Sports Medicine (ACSM, 1998) to decrease one's risk for cardiovascular disease. Despite appearing in excellent health, the dietary intake of endurance athletes may be sub optimal, due to training and racing energy expenditure. Hawley, Dennis, Lindsay, and Noakes (1995) found a majority of runners (track and field athletes and marathoners) eating fewer carbohydrates than recommended by sports nutritionists, which can decrease endurance and lengthen recovery after intense competition. The same study found that female runners had inadequate calorie intake to meet energy expenditure and were low in dietary calcium, iron, vitamin B12, and zinc. In contrast, male runners balanced calorie intake with energy expenditure and met the RDA for all vitamins and minerals.

Research examining the nutritional practices of elite athletes reviewed 22 dietary intake studies which, when combined, examined 50 groups of elite athletes (Economos, Bortz, & Nelson, 1993). Economos et al. divided the athletes into groups based on the type of training and sport in which they competed. The recommended energy intake for male endurance athletes was 50 kcal/kg/day, and 45-50 kcal/kg/day for female endurance athletes. The recommended caloric intakes were based on a training schedule of a minimum of 90 minutes per day of continuous aerobic training. Overall, Economos et al explained that with sufficient intake of calories, protein supplementation is not needed. Additionally, athletes with high caloric expenditures, such as cyclists and triathletes, should consume higher amounts of fat in their diet (25-30%) to meet energy needs. The authors concluded that valid scientific data regarding the dietary intake of elite athletes is limited, and it remains unclear whether elite athletes understand and follow nutritional recommendations.

An additional indication that nutritional understanding may be compromised in athletes is the finding of nutrition-related immunosuppression in athletes who maintain a heavy training and competition schedule. In a recent study by Bishop, Blannin, Walsh, Robson, and Gleeson (1999), the role of nutrition in immunosuppression was examined. The authors discussed the tendency for athletes to adopt fad diets based on information from the media or misinterpretation of published scientific data. Also, the authors addressed the subject of vitamins and minerals that are marketed as performance-enhancing supplements despite the lack of scientific data to support such claims. Combining poor nutrition with a heavy, high intensity, training schedule can increase an athlete's risk for opportunistic infection based on a suppression of the immune system (Bishop et al., 1999).

Nutrition Recommendations for Endurance Athletes

The dietary recommendations for endurance athletes include adequate nutrients for tissue maintenance, growth, and repair, combined with additional calories to meet the energy demands of their specific sport. The ADA/ACSM (2000) position stand, "Nutrition and Athletic Performance," states that optimal nutrition enhances physical activity, athletic performance, and recovery from high intensity training or competition. Nutrition and Athletic Performance (ADA/ACSM, 2000) chronicles research on the energy needs of athletes, macronutrient and fluid needs, special nutrition for training, supplements, ergogenic aids, and recommendations for vegetarian athletes. Using this large body of research, the ADA/ACSM (2000) reported that to ultimately improve endurance sport performance, athletes should practice good nutrition and hydration habits, use supplements and ergogenic aids carefully, and eat a wide variety of foods in adequate amounts to meet individual energy expenditures from training and competition.

The caloric expenditure of elite endurance athletes during training and competition can average 2 or 3 times the energy expenditure of an average adult. By balancing energy intake and expenditure, endurance athletes can maximize performance, maintain blood glucose levels, avoid glycogen depletion, and improve recovery time (McArdle et al., 1996). Generally speaking, the recommended percentages of macronutrients are as follows: carbohydrate at 50-65%, protein at 15% and fat at 30% or less of total caloric intake (McArdle et al., 1996). Most recently, the ADA/ACSM (2000) Nutrition and Athletic Performance position stand recommends carbohydrates at 55-58%, protein at 12-15% and fat at 20-25% of total calories.

The recommendation for 30% or fewer total calories from fat is based on the promotion of health in the general population, not necessarily performance in endurance athletes. The effects of dietary fat and endurance sport performance have only recently been examined (Brown & Cox, 1998). In "Nutrition and Athletic Performance," the ADA/ACSM (2000) recommend a diet that is 20-25% fat, to provide essential fatty acids, fat-soluble vitamins, and calories for energy. It has been determined that diets with less than 15% fat do not provide an advantage for endurance athletes (ADA/ACSM, 2000).

The protein recommendation of 12-15% of total calories (ADA/ACSM, 2000) is slightly elevated above the RDA (10-12% protein) to spare protein, so that it is not utilized as energy calories during heavy endurance training. Exactly how much protein an endurance athlete needs is not well researched, although general recommendations are reported. The ADA/ACSM (2000) recommend increasing from 0.8 g of protein per kg of body weight (average adult protein intake) to 1.2 – 1.4 g of protein per kg of body weight for endurance athletes. With very high protein intakes, the break down of excessive protein causes increased metabolic work, dehydration, and strain on the kidneys to excrete nitrogen (Krause, 2000).

Carbohydrate levels in the diet have been researched extensively, due to the direct effects of dietary carbohydrate on muscle glycogen stores. The general recommendation for athletes engaging in heavy endurance training is 10 g of carbohydrate per kg of body weight (Mc Ardle et al., 1996). This recommendation for dietary carbohydrate corresponds to approximately 60-65% of the total energy intake. The ADA/ACSM (2000) suggest that carbohydrate intake for endurance athletes is sufficient at 55-58% of total calories (the same recommendation for all Americans), since their total daily energy intake is high. In other words, 55-58% of 4000 calories per day is equal to 550-580 g of carbohydrate, which is within the recommendation of 500-600 g of carbohydrate a day to maintain optimal glycogen stores (ADA/ACSM, 2000). Carbohydrate loading regimes have been tested to determine the best way to maximize glycogen storage prior to endurance competition, especially with successive days of heavy training (McArdle et al., 1996). It is recommended that a prerace meal provide 200-300 g of carbohydrate, 3-4 hours before the competition begins. Additionally, 30-60 g of carbohydrate should be consumed per hour during the race or training. To replenish glycogen after training or racing it is recommended to consume 1.5 g of carbohydrate per kg of body weight in the first 30 minutes following exercise and every 2 hours for the next 4-6 hours (ADA/ACSM, 2000).

Additional nutrition concerns for endurance athletes include fluids, vitamins, and minerals. Athletes should be well hydrated, and can measure body weight before and after exercise, and evaluate the color and volume of urine to assess hydration status. The ADA/ACSM recommendation for hydration in endurance sport is for athletes to consume 400-600 ml of fluid 2 hours before exercise and continue drinking 150-300 ml every 15-20 minutes during exercise. Following exercise, the goal of fluid consumption is to replace sweat losses, drinking 150% of lost body weight (ADA/ACSM, 2000). Nutrition and Athletic Performance (ADA/ACSM, 2000) report that vitamin and mineral supplements are not needed if a diet adequate in energy, with a wide variety of foods, is consumed regularly. If the athlete restricts caloric intake or eliminates one or more food groups from the diet, a multivitamin supplement may be warranted (ADA/ACSM, 2000).

Sobal and Marquart (1994) conducted a review of literature examining the prevalence and patterns of supplement use among athletes. Thirty-eight studies were reviewed, 21 of which examined elite athletes. In the population of elite athletes, 59% reported using supplements, well above the usage by college athletes at 43% and high school athletes at 47%. Researchers stated that athletes competing at the highest level were more likely to use supplements as ergogenic aids (Sobal & Marquart, 1994). When the data were analyzed by sport, endurance athletes exhibited moderate use of supplements with 48% of triathletes, 42% of runners, and 42% of cyclists reporting supplement usage.

Nutrition Understanding and Information Sources in Endurance Athletes

Elite level endurance athletes follow specific, elaborate, training programs to enhance performance. Sophisticated measurements of maximal oxygen consumption and anaerobic power are used to evaluate performance capabilities and measure changes induced by training. Research has quantified the effects of a multitude of training programs, exercises, and specific drills, and produced training recommendations for each endurance sport. Training frequency, intensity, and duration recommendations are explicit for different endurance sports and various types of competition within a sport. In contrast, research in the area of nutrition has produced general recommendations that provide percentages of protein, carbohydrate, and fats in an optimal diet for adults, and it is recommended that athletes follow the same recommendations but increase the total number of calories as needed to meet energy expenditure (ADA/ACSM, 2000). Nutrition recommendations specific to endurance sport are limited, focusing primarily on carbohydrate intake to enhance glycogen storage and hydration. Research that examines the direct effects of optimal nutrition on endurance sport performance is very limited. Despite the fact that training and nutrition are the two factors most important in determining athletic performance (Hoffman & Coleman, 1991), it seems that training has received significantly greater attention from athletes, coaches, and researchers. The specificity of training makes it easier to research and quantify, as a motivated athlete wants to train and, in most cases, will simply follow the training program. It would seem that an athlete would understand the effects of an optimal training diet and be able to follow the dietary plan specifically, but research indicates there is a difference between what athletes say they eat and what is actually consumed (Schoeller, 1995). Evidence that endurance athletes are given dietary plans as part of their training programs is not present in the literature.

A study examining the nutrition knowledge of college coaches found that although the coaches scored an average of 70% on a nutrition knowledge test, confidence in their responses was low, with only 33% of coaches answering with a high degree of certainty (Corley, Demarest-Litchford, & Bazzarre, 1990). The 15 nutrition questions were true-false, and the participant then ranked the degree of certainty for each answer (three choices). Demographically, the coaches who participated in this study (N=105) averaged 9 years of coaching experience, and 72% held degrees in physical education. However, 82% of the coaches had never taken a college level nutrition class. Books and textbooks were the most common nutrition information source utilized by the coaches surveyed. Coaches reported a 2% usage of dieticians and nutritionists. It is quite possible that nutrition professionals are not available to college coaching staffs. Up until 1997, Penn State University was the only college in the United States to employ a full-time sports nutritionist (Clark, 1999).

Unless an athlete specifically seeks out a sports nutritionist familiar with endurance sports, the information available may be based on recommendations for the general public. An example of this trend is found in a study by Burke, Gollan, and Read (1991) that examined dietary intakes and food use in elite Australian male triathletes and marathon runners. Among 25 triathletes, 8 sought professional dietary advice and the majority relied on their peers, magazines, and books. The entire group expressed interest in the effects of nutrition on performance and felt a very low fat diet was advantageous to performance in endurance sports. The marathon runners (n=19) relied on the same sources for nutritional information, and expressed belief in a very low fat diet, with 15% or fewer total calories derived from fats. Both the triathletes and the runners were very familiar with the Pritikin diet and theory, which is a very low fat, high fiber diet plan for individuals at risk for heart disease. Burke et al. discussed the tendency of endurance athletes to exclude a single nutrient or over-emphasize a single nutritional issue instead of focusing on the overall nutritional plan. However, the endurance athletes exhibited a high level of nutritional awareness and were conscious of the importance of nutrition in relation to performance, making them a suitable population for nutrition education. Although details of the nutrition education plan were not discussed, the authors stated it should focus on meeting dietary goals with a varied dietary intake that integrates nutritional issues important to endurance sport (Burke et al., 1991).

It is unclear whether endurance athletes possess the nutritional knowledge and understanding to combine an optimal dietary intake with their training programs. Additionally, will endurance athletes seek professional help with nutrition to improve their performance, or do they rely on the media, the Internet, coaches and/or teammates as nutritional resources? Lastly, are endurance athletes routinely taking in the nutrients they need for optimal performance, and are they aware of the consequences of failing to meet nutritional needs?

Female Endurance Athletes and Nutrition

Studies of females that compete in endurance sports such as cross country running, cycling and triathlon have found that many variables affect dietary intake and nutritional status. The nutritional practices of female athletes are not always selected for performance, and many psychosocial influences can alter the dietary intake of female athletes, despite knowledge of good nutrition principles. Frederick and Hawkins (1992) compared the nutrition knowledge, attitudes, and dietary practices in three groups of females: postmenopausal women, college athletes (dancers and track athletes), and nonathletic college students. The study was based on previous evidence that dietary behavior is more strongly affected by attitudes toward nutrition than by nutrition knowledge or training. This research utilized a nutrition knowledge test, an attitude survey, a 24-hour food recall, a food frequency questionnaire, and a personal information questionnaire. The track team members had the highest anorexia/bulimia behavior scores on the attitude survey, as well as the highest energy expenditures while training. The primary source of nutrition information for the female track athletes was the media, followed by parents and friends. Nutrition knowledge scores were lowest in dancers, and second lowest in track athletes. Both nonathletes and postmenopausal women scored significantly higher on the nutrition knowledge test when compared with the athlete group ($p < .05$).

In a study by Edwards, Lindeman, Miesky, and Stager (1993), energy balance was measured by doubly labeled water in a group of highly trained female endurance runners ($\underline{n}=9$). The women were college-age cross-country runners with a mean body fat of 13%

(SD=3.2). All subjects kept a detailed food and activity record over a 7-day period. The energy intake reported in the dietary log represented 68% of the energy expenditure measured by the doubly labeled water technique. Using the Pearson product-moment correlation, Edwards et al. found a strong, negative correlation (r= -0.83) between energy expenditure and reported food intake. This finding is explained by additional significant correlations (r= 0.82) between body weight and energy expenditure combined with the correlation (r= -0.74) between body weight and energy intake. Simply put, heavier individuals expended more calories for the same level of exercise, yet the heavier athletes reported the least food intake. The authors determined that the underreporting of food intake was influenced by a lower body image in the heavier women, despite the fact that being heavier was due to being taller, not having higher body fat levels.

In a paper detailing nutrition assessment of athletes, Storlie (1991) discussed psychosocial factors that influence an athlete's actual nutritional behaviors. Primary areas that may influence an athlete's eating habits and behaviors toward eating include social influences, self-concept, competitive goals and commitment, and attitudes or philosophy toward life. Storlie stated that social influences such as family and friends could be a positive form of support or a negative source of conflict, contributing to the athlete's anxiety level or obsessive behaviors toward exercise and food. Additionally, other role models such as celebrities, coaches, and peers may influence an athlete's attitude toward nutrition and, therefore, alter dietary patterns.

Nutrition and Cyclists

Cycling is considered a mentally and emotionally challenging sport. Often in defeat, athletes believe they were just not "tough enough," yet how many poor performances are related to nutrition related inadequacies? Research has demonstrated that a 1.8% decline in body weight due to water loss impairs endurance sport performance (Gatorade Sports Science Institute, 2000). Additionally, an elite cyclist can deplete muscle and liver glycogen stores by more than 50% in 1 hour and completely in 2 hours if glucose is not supplemented while racing (Gatorade Sports Science Institute, 2000). The direct effects of hydration and glycogen status in endurance athlete should be enough to inspire athletes to seek nutritional guidance. In a review, Burke (1995) listed multiple factors that could impair an athlete's use of sound nutritional practices: poor understanding of sport nutrition, failure to recognize nutritional requirements in one's self, lack of general nutrition knowledge, travel, busy lifestyle, and inadequate finances.

A study by Garcia-Roves et al. (2000) utilized professional road cyclists and evaluated dietary intake during training and competition. In this study, the authors stated that the nutritional status in professional cyclists is determined by food choices and knowledge of sports nutrition. At the professional level, the team doctor is responsible for the nutrition of the athletes, hopefully improving nutritional status above that of amateur cyclists. Garcia-Roves et al. (2000) detailed the typical eating behavior of 14 cyclists during high intensity training and competition. All food intake was weighed or measured to increase accuracy of the dietary records taken by the experimenters. The eating pattern consisted of four periods: breakfast, during the race, after the race, and supper. During training, cyclists consumed an average of 5,470 kcal (SD =358) per day, comprised of 60.8% carbohydrates (SD =3.0%), 14.4% protein (SD =1.0%) and 25.3% fat (SD = 2.2%). While competing, cyclists consumed an average of 5,350 kcal (SD = 406) per day, comprised of 57.7% carbohydrate (SD = 2.8%), 13.2% protein (SD = 0.8%), and 29.9% fat (SD = 3.2%). Analysis of the data revealed a significant difference ($p \leq .05$) in protein intake between training and competition, but no significant difference ($p = 0.057$) in fat intake. The researchers found that the increase in protein was based on increased consumption of cereals at breakfast and more meat at supper. The increased cereal consumption during competition contributed an average of 40 g protein. The increase in fat was primarily attributed to increased intake of cookies, candy, and cakes during competition. The increase in sugary, fatty foods corresponds to the high-energy intake needed to meet the energy expenditure of racing 5-7 hours per day. In conclusion, Garcia-Roves et al. emphasized the importance of having a sport nutritionist, dietician, or team doctor with knowledge of sport nutrition to guide the athletes' eating behaviors.

Jensen et al. (1992) investigated the dietary intakes of male endurance cyclists during training and racing by examining 14 cyclists competing at the collegiate level. The cyclists were racing at a category level of 2 or 3 in US Cycling Federation competitions. Researchers reported that carbohydrate intake comprised 60% of total calories, protein 13-14%, and fat less than 30% of total calories. The authors conducted this study based on results from a Nationwide Food Consumption Survey conducted in 1977-78 by the U.S. Department of Agriculture that reported men aged 19-22 years consume approximately 250 g of carbohydrate a day. The concern that endurance athletes consuming such a low level of carbohydrates would inhibit recovery from training prompted the authors to conduct a study to quantify the food intake of competitive male cyclists to accurately determine percentages of macronutrients consumed. Although overall energy intake was not compared with energy expenditure in this study, mean daily energy intake was approximately 60 kcal/kg of body weight and exceeded 4,000 kcal per day during training and racing periods. The authors described the cyclists' diets as excellent, and made a comparison to the less than optimal dietary intakes found in female athletes at the same level of competition and athletes in other sports. Investigation into nutritional knowledge of this group of athletes was not pursued in this study.

Due to the demands of training and competition, energy expenditure is very high in endurance athletes, especially cyclists. Professional cyclists can expend above 6,000 kcal per day in training, and energy expenditure increases during competition. In a long duration stage race, such as the Tour de France, cyclists have been found to expend upwards of 9,000 kcal per day. On the average, endurance athletes, including cyclists, expend between 3,000 and 4,000 kcal per day (McArdle et al., 1996). A study examining the dietary intake of two male cyclists during a 10-day ride covering 2,050 miles found an average caloric intake of 113 kcal/kg of body weight per day (Gabel, Aldous, & Edgington, 1995). Compared with a training recommendation of 50 calories per kg of body weight (Economos et al., 1993) for male endurance athletes, 113 kcal/kg represents more than a two-fold increase during competition for cyclists. Based on energy expenditure alone, it is crucial that cyclists not only be knowledgeable about nutrition, but also be able to apply the nutrition recommendations to optimize their dietary intake during training, racing, and recovery.

In a nationwide survey conducted in the Netherlands, the nutritional habits of elite athletes were examined (van Erp-Baart et al., 1989). The survey was conducted to describe the typical dietary pattern of competitive athletes, including cyclists. The cyclists in this study maintained a 4-day food record and were analyzed on three separate occasions to account for changes in dietary intake related to competition and training. The cyclists provided additional information about training and competition to quantify energy expenditure. The results of this study indicated that the carbohydrate intake of cyclists was 55% of total calories; significantly lower than the Dutch RDA recommendation of 60-65% of calories from carbohydrates. Fat intake was less than 25%, and protein intake was greater than the Dutch RDA of 1.5 g/kg of body weight. The cyclists in this study competed in extended duration stage races, resulting in extremely high caloric expenditures. A large percentage of the caloric intake (18.8%) was derived from carbohydrate supplements. The authors discussed the validity of dietary records completed by participants, acknowledging the limitations in the method of data collection, including dietary underreporting.

Research on cyclists examined the effects of changes in dietary macronutrients on sport performance. In a study conducted by Brouns et al. (1989), 13 highly trained, male cyclists were evaluated over 2 days of exhaustive cycling. All subjects consumed a normal, carbohydrate-rich diet that consisted of 50-60% carbohydrates, 15% protein, and 25-30% fat. The 2 days of exhaustive cycling were designed to expend the same amount of energy as 2 days during the Tour de France race. The study evaluated metabolic changes in cyclists on a normal diet compared with a normal diet supplemented with concentrated carbohydrate liquids. The results indicated that the subjects who did not have additional carbohydrate supplements (concentrated liquids) were unable to maintain energy balance. The two main factors that defined performance capacity were energy balance and carbohydrate availability. During a competition as intense as the Tour de France, energy balance can only be maintained with concentrated carbohydrate supplements, despite a normal diet that is rich in carbohydrates. The authors concluded that carbohydrate supplementation resulted in greater availability of carbohydrates, which spared glycogen and increased exercise time to exhaustion. Additionally, glycogen stores can be replenished within 24 hours after exercise and protein degradation during exercise is reduced.

Research has attempted to examine the effects of pre exercise meals of various compositions on subsequent performance during endurance exercise. Whitley et al. (1998) evaluated the effects of a high fat and a high carbohydrate meal on a 90-min endurance exercise session, followed by a 10-km time trial. Eight highly trained cyclists with maximal oxygen uptakes between 65.0-83.5 ml/kg/min were evaluated three times. During the first session, cyclists were fed a high carbohydrate pre exercise meal. During the second session a high fat pre exercise meal was consumed and the third session evaluated cyclists while fasting. All of the participants fasted prior to the exercise sessions, and the meals were assigned randomly. Four hours after the meal, the participants exercised for 90 min at 70% of their VO2 max. After a 3-min recovery period, the cyclists completed a simulated 10-km time trial. The metabolic data indicated that the pattern of substrate oxidation was unaltered by the availability of different levels of fatty acids and glucose prior to exercise.

Brown and Cox (1998) designed a study that evaluated the effects of a high fat diet compared with a high carbohydrate diet over a 3-month period. The high fat diet derived 50% of total calories from fat, primarily saturated, and 37% from carbohydrate. Compared with the standard recommendations for endurance athletes, this diet can be considered extreme and possibly harmful if plasma lipids are significantly elevated. The high carbohydrate diet consisted of 69% of total calories from carbohydrates and 15% from fat, which corresponds to a high carbohydrate, low fat routinely utilized by endurance athletes. Participants were 32 endurance-trained cyclists, randomly assigned to the high fat or high carbohydrate group. To promote adherence to the diet, participants received individual nutrition counseling and a food ration that corresponded to the assigned diets. All cyclists were in the off-season and held training constant over the 12-week diet period. Plasma lipids and lipoproteins were measured at baseline, and at 4, 8, and 12 weeks. Body composition was assessed at baseline and at 12 weeks using dual energy x-ray absorptiometry. Maximal oxygen uptake was measured at baseline and again at the completion of the diet manipulation. The high fat diet did not alter plasma lipids or lipoproteins, demonstrating the endurance athlete's adaptation to the high fat diet. Triglycerides were elevated in the high carbohydrate diet group. Body composition was unchanged in both groups, dispelling the idea that a high fat diet will cause an athlete to have an increase in body fat. Although high fat diets are associated with an increased risk for coronary heart disease in the general population, this study suggests that elite endurance athletes responded differently. In inactive individuals, 12 weeks on a 50% fat diet can be predicted to increase LDL cholesterol by approximately 39%. The authors stated that in individuals with high levels of physical activity, the hypercholesterolemic effect of a diet high in saturated fat is blunted. Since body composition was maintained despite an increase in calories from fat, the results of this research are directly applicable to the endurance athlete. During training or competition that drastically increases caloric expenditure an athlete can increase dietary fat to meet increased caloric needs without added health risk or increased weight from body fat.

Competitive endurance athletes, including cyclists, are susceptible to claims that ergogenic aids improve performance, and when one supplement does not work a new, improved supplement comes along (ACSM/ADA, 2000). The American College of Sports Medicine and the American Dietetics Association position stand on nutrition and athletic performance (2000) advises athletes not to use nutritional ergogenic aids (supplements included) until they have discussed it with a qualified nutrition or health professional. Taking pills and drinking beverages may seem like the easy way to improved endurance, recovery, and overall performance, and the Internet has made a greater number of products available than ever before (ADA/ACSM, 2000). The following studies examined the theories upon which claims are made for several common ergogenic aids marketed to cyclists.

Rokitzki, Logemann, Huber, Keck, and Keul (1994) examined the effects of antioxidant supplementation in 36 elite, competitive cyclists during a high intensity training camp. Using a double-blind approach, subjects were split into two groups with one group serving as the control. Alpha-tocopherol (vitamin E) was given in capsule form to the experimental group; the control group received placebo capsules. Total supplementation was 330 mg per day for 5 months. Plasma concentrations of alpha-tocopherol were measured prior to the study and after 151 days of supplementation, levels increased significantly. Exercise testing was conducted prior to the start of the study and repeated after 151 days of supplementation. The exercise testing protocol was an incremental test on a cycle ergometer. Participants began cycling at an intensity of 100 watts, with increases of 50 watts every 5 min, to the point of exhaustion, which occurred between 30 and 40 min. During the exercise test, blood samples were collected every 5 min to calculate lactate threshold levels. Results indicated that a performance-enhancing effect of alpha-tocopherol was not present, despite increases in serum levels following supplementation.

Another ergogenic aid, ENDUROX, claims to enhance performance in endurance sports by altering metabolism so the body uses fat instead of carbohydrate (lipotropic effect), increasing oxygen consumption, reducing lactate, and improving heart rate recovery time. Cheuvront, Moffatt, Biggerstaff, Bearden, and McDonough (1999) investigated ENDUROX's claims, using a double blind, crossover, research protocol. Ten males were randomly assigned to the experimental group, consuming 800 mg of ENDUROX, or the placebo group, consuming 400 mg of placebo capsules for 7 days, followed by a 7 day period without supplementation, and lastly, a 7 day period with reciprocal conditions for the two groups. Participants performed a cycling protocol, riding for 30 min at a low intensity, followed by 10 min at a high intensity and 15 min of recovery following each 7-day supplementation period. Variables monitored included oxygen consumption, minute ventilation, respiratory exchange ratio, heart rate, rating of perceived exertion, blood lactate, and serum glycerol. All variables were analyzed using a repeated measures two-way ANOVA. With no significant differences found between treatments for any of the variables evaluated, researchers ruled ENDUROX's performance and recovery claims to be inaccurate, though a measure of practical significance was not reported.

Summary

Research examining the nutritional knowledge and practices of elite, competitive cyclists is limited. Specific nutritional recommendations for energy intake, macronutrients, and fluids have been designed based on research in exercise physiology and nutrition. The importance of determining the level of nutritional understanding and knowledge in endurance athletes is warranted by the presence of suboptimal dietary intake in a wide range of athletes. In elite cyclists, nutritional knowledge and understanding may be the key to a successful race and competitive season. Studies of females have found that many variables affect dietary intake and nutritional practices, including psychosocial influences, despite nutrition knowledge and understanding.

CHAPTER III

Methods

This chapter provides detailed information on instrument development, modification and qualitative review of the modified survey. Sampling and data collection protocols are outlined and statistical analyses are described.

Instrument Development

A survey instrument created by Shifflett, Timm, and Kahanov (2001) to examine understanding of athletes' nutritional needs among athletes, coaches, and athletic trainers was modified for this study. The original survey (Shifflett et al., 2001) underwent rigorous assessment, including two qualitative reviews followed by revisions, a pilot study to evaluate the nutrition items using item analysis, revision of items with poor discrimination indices, and repeated qualitative review. The survey, after revision, consisted of three sets of items: demographic / background items ($\underline{n}$ =10); perceived understanding of nutrition, importance of a healthy diet, and nutrition information sources (n=4); and a nutrition knowledge component ($\underline{n}$ =20).

The survey modified for this study consisted of five sets of items: nutrition information, a nutrition knowledge and understanding component, demographics, competition information, and training information. The nutrition information section ($\underline{n}$ =1) solicited data on the top three nutrition information sources the participant utilized. The nutrition knowledge and understanding component ($\underline{n}$ =25) was comprised of 16 items from the instrument developed by Shifflett et al. (2001). Four of the 16 items were revised. Two new items examining general nutrition knowledge and understanding were created. An additional seven items, specific to the nutritional needs of elite, competitive cyclists, were created. The demographics section (n =4) asked for the respondents' age, height, weight, and sex. Sex was included to ensure that only males would be in the participant pool. The competition section (n =4) asked for information about the cyclists' current racing category and years at that level, years at or above category 3, and years in competitive cycling. Lastly, the training section (n =4) gathered information pertaining to frequency, duration, and parameters monitored during training. Demographics, competition, and training information were used to describe the respondents and to explore data trends.

The survey was reviewed by professors in nutrition that specialize in sports nutrition for elite, endurance athletes, including cyclists. Following the qualitative review by two independent professors, revisions were made based on feedback received. Revisions to questions 1, 4, 6, 7, 12, 15, 22, 23, and 24 were made. The correct answer for question 1 was revised, rewording distractor "a" to be more consistent with the wording used on the food pyramid. Question 1 dealt with number of servings from each food category; the distractor was changed from "apples, bananas, and grapes" to "fruits and fruit juices." Question 4, on fluid consumption, was altered so that there was a greater difference between the volumes listed as distractors. On question 6, distractor "b" was made more specific, changing it from "increase protein intake" to "increase protein intake to 30% of total calories." For question 7, it was recommended to add "(sodium depletion)" after the word hyponatremia, as some participants might not be familiar with the term. Distractor "a" on question 12 was reworded, changing "complex sugars" to "complex carbohydrates" to be chemically correct. Question 15 dealt with the percentage of calories from fat, with the correct answer being 20-25%, and the distractors being toward the extremes at 5-10%, 10-15% or the general population recommendation of less than 30% of calories from fat. Both experts changed question 22, making it more specific. The original question asked which answer represented "a pre competition meal to maximize stored carbohydrates." The revised question included additional information, " pre-competition meal consumed 4 hours before a race to maximize stored carbohydrates;" the foils (correct answer and distractors) remained the same. Originally, question 23 asked, "How many calories are expended on a 2 hour, moderate intensity training ride?" One expert raised the point that energy expenditure depends heavily on body weight and maximal oxygen consumption; thus the question was too complex for a single correct answer. The question was rewritten so that it inquired, "What factors should be considered when estimating caloric expenditure?" Lastly, question 24 was identified as not specific enough; the expert recommended adding information about the available post race recovery time. The original question asked about recovery following a "competitive cycling race; the revised question was specific, ("after completing day 1 of a 2 day stage race"), and the foils remained the same.

Sampling

Upon approval from the Human Subjects Institutional Review Board, a call for research participants letter, on San Jose State University letterhead, was sent to USA Cycling and the United States Cycling Federation. Additional letters were sent by e-mail to road racing teams, cycling clubs, certified cycling coaches, and road race directors across the United States. Interested individuals and teams responded by sending mailing address information to the researcher. A letter of informed consent, on San Jose State University letterhead, and the nutrition survey were mailed to potential participants and cycling coaches who requested surveys for their category 1, 2, and 3 riders. Additionally, a letter of informed consent and the nutrition survey were provided by e-mail, in an Adobe Acrobat PDF file that the participant could print, fill out, and return by fax or mail, using the fax number or address listed on the last page of the survey. Another option for participants with Adobe Acrobat was to complete the survey and return it by e-mail.

Data Collection Protocols

Surveys were returned using a self-addressed, stamped envelope provided to the respondents who requested surveys by mail. Respondents who requested surveys by email, faxed or mailed the survey to the researcher, using the fax number or address listed on the last page of the survey. The returned surveys were assigned identification numbers, and demographic, competition, and training information was summarized for the entire group. Surveys returned by male, category 1, 2, and 3 riders were utilized for this study. Given the multiple factors that influence nutrition practices and nutrition understanding in female athletes, this study decided to begin investigation of the subject with males. Surveys from other cyclists were not included.

Statistical Analysis

Measures of central tendency and variability were determined for descriptive data and nutrition scores. A nutrition understanding and knowledge score was determined for each participant, recording the number of correct responses and a percentage score that indicated the number of correct answers out of total questions. Cross tabulation was utilized to examine trends in nutrition scores, answers to nutrition understanding questions, and descriptive data by racing categories and by years of experience groupings. Nonparametric tests of differences were conducted to examine differences in nutrition score by racing category and years of experience groupings. Nutrition information sources were examined for relationships with racing category and years of experience groupings. Additional cross tabulations between nutrition information source by racing category and years of experience groupings were conducted. All statistical analyses were conducted using SPSS version 10.

Descriptive Information on All Participants. Median age, height, and weight for category 1, 2, and 3 riders and the entire group were determined. Median values for competition data: years in current racing category, years racing at or above category 3, and total years of competitive cycling experience were determined. Training data for the entire group and for category 1, 2, and 3 riders were analyzed using measures of central tendency and variability (medians and standard deviations). Median values for number of riding days per week, weekly training mileage, and number of hours ridden per week were determined. Cross tabulations of riders in each racing category with monitoring heart rate, cadence, and/or power were determined.

Descriptive Information on Nutrition Component. The median nutrition scores (number of correct answers) and median proportion nutrition scores were determined for the entire group and for category 1, 2, and 3 riders. Using cross tabulation, the top three sources of nutrition information selected by category 1, 2, and 3 riders and the entire group were summarized. Responses to each question from the nutrition survey were cross tabulated with racing category.

Descriptive Information on Subgroups of Participants. Additionally, the participants were examined using an alternate grouping, based on years of experience in competitive cycling. The grouping consisted of participants with 0 to 6 years, 6-11years, and 11 or more years of experience as competitive cyclists. Median age, height and weight for each group were determined. Median values for competition data, years in current racing category, years racing at or above category 3, and total years of competitive cycling experience were determined. Training data for each group (years of experience) was summarized using measures of central tendencies (medians). Median values for number of riding days per week, weekly training mileage, and number of hours ridden per week were determined. Cross tabulations of riders in each grouping with monitoring heart rate, cadence, and/or power were determined.

Descriptive Information on Nutrition Components by Subgroups. The median nutrition scores (number of correct answers) and median proportion correct were determined for the years of experience groupings. Using cross tabulation, the top three sources of nutrition information selected by each years of experience grouping were evaluated. Responses to each question from the nutrition survey were cross tabulated with years of experience groupings.

Analyses Relating to Main Problem. Although the homogeneity of variance assumption was met, the normality assumption was violated and nonparametric statistics were utilized for data analysis. A Kruskal-Wallis test for significant differences in medians of each category of racing was conducted. Using the years of experience in competitive cycling groups, a Kruskal-Wallis test for significant differences in medians was also conducted.

The nutrition information source section of the survey asked participants to rank order the top three sources of information they rely on regarding nutrition. The number of times an information source was selected as a 1st, 2nd or 3rd choice was totaled. Racing category and top nutrition information source were cross tabulated.

Analyses Pertaining to Related Problems. Cross tabulations were conducted on each question (n =22) from the nutrition understanding and knowledge section of the survey with racing category and the years of experience grouping. These data were evaluated to determine which type of nutrition questions were missed a greater percentage of the time for the entire group, by racing category, and by years of experience grouping. Nutrition information sources were placed in three groups: high-level, medium-level and low-level. The high-level source group contained professional sources of information and primary research sources, representing the top level of information. The high-level source group consisted of sports nutritionist, registered dietician, college nutrition/health classes and academic journals. The medium-level source group contained web sites, magazines and coaches. Although web sites and magazines can provide accurate information, both offer an equal or potentially greater opportunity to provide misinformation to cyclists. Coaches were included in the medium-level group since nutritional knowledge of coaches varies substantially, based on education and background. The low-level source group consisted of family, teammates and "other." The low-level group represents sources most likely to provide unsubstantiated nutrition information. Cramer's V was utilized to examine the relationship between racing category and first choice for nutrition information (high, medium or low level sources). Racing category and first choice for nutrition information were cross tabulated, as were years of experience and first choice for nutrition information (high, medium or low level sources).

Summary

This chapter detailed the methods used to conduct this study. Instrument development, sampling, data collection protocols and statistical analyses are described. The data was examined by racing category, as well as by years of experience groupings.

CHAPTER IV

Results

This chapter reports the assessment of the survey instrument, descriptive data, nutrition survey data, and nutrition understanding and knowledge scores for the entire group and categories 1, 2, and 3 cyclists. Results of analysis of statistically significant differences between nutrition scores for category 1, 2, and 3 are reported. The top 3 choices of nutrition information utilized by elite cyclists are reported. The relationship between racing category and first choice nutrition information source is examined. Responses to nutrition understanding and knowledge questions are analyzed to determine the type of questions most frequently missed by the entire group.

Assessment of Survey Instrument

An item analysis of the nutrition knowledge and understanding section was conducted identifying weak items based on corresponding discrimination indices. The item analysis of the 25 nutrition questions identified 3 weak items (discrimination indices < .10); the items were eliminated, reducing the length of the survey to 22 nutrition questions. Question number 3, an eliminated item (discrimination index= .03), asked about the protein needs of an endurance athlete.. The correct choice (c) for question 3 was selected by 36% of the cyclists, while 64% choose a distractor (incorrect response, d) that was worded to include the correct answer and an incorrect distractor ("a and c"). However, not one participant selected the distractor "a" as the answer. The item analysis details the responses to each question, providing the choices of the top scoring 27% of the respondents (top group) and the bottom scoring 27% of the respondents (bottom group). For question 3, the top group chose incorrect response "d" 73% of the time, and the bottom group chose incorrect response "d" 73% of the time. Question 23 asked about estimating caloric expenditure and what variables should be considered. The correct answer was "maximal oxygen consumption and body weight" ("b and c" respectively). Question number 23 (discrimination index= .06) was eliminated; the top group chose the correct response 27% of the time, with 45% choosing distractor "c", when the correct answer was "d" and that answer consisted of "b and c". Of the top group, 9% choose distractor "b", which is part of the correct answer. The final question, #25, was eliminated (discrimination index= .02); the low scoring group chose the correct answer 45% of the time, while the top scoring group chose the correct answer 64% of the time. Within the top scoring group, 27% chose distractor "e", which was "all of the above". Coefficient alpha, used to assess the internal consistency of the survey, was found to be 0.66.

Descriptive Data

The descriptive data from the demographics, competition, and training sections of the nutrition survey were summarized. Total responses (N=47) to the survey included eight category 1 (includes professionals) males, fifteen category 2 males and eighteen category 3 males, one category 5 male, one category 1 female, two category 2 females, and two category 3 females. This study was delimited to category 1, 2, and 3 male cyclists, therefore, the category 5 male and all female responses were not included. The total number of category 1, 2, and 3 male riders responding was 41.

The demographic data collected included age, height, and weight. The median age, height and weight of participants and by racing category are reported in Table 1. Competition data included information about experience in the rider's current category, as well as total racing experience. Cyclists reported years in their current racing category, years of racing experience at category 3 or above, and total years of competitive cycling experience (racing in any category, 1-5), medians and standard deviations are summarized in Table 1. Training data included number of training days, weekly training mileage, and total weekly training hours. Since respondents often reported a range of hours and mileage for the week, such as "15-20 hours and 200-250 miles (321.8-402.3 km)," the average values, "17.5 hours and 225 miles (362.0 km)." were utilized for each participant. The median number of training days, weekly mileage, and weekly training hours are summarized in Table 2. Additional training information included asking participants if they monitored heart rate, cadence and/or power during training rides. These data provided descriptive information about the group and their training practices. Of the total participants, 79% reported monitoring heart rate, 60% reported monitoring cadence, and 21% reported monitoring power while training. The percentages of respondents that monitored heart rate, cadence, and power by racing category are reported in Table 2.

Nutrition Survey Data

The median score for the entire group was 12 correct answers. Both category 1 and category 3 cyclists had a median score of 12, while category 2 cyclists had a median score of 15 correct answers. The median percentage score for each category was

Table 1

Participants' Median Age, Height, Weight, and Years of Experience

	Category 1	Category 2	Category 3	Total Group
Age in years	27.5 (3.5)	33.0 (4.7)	32.5 (7.3)	32.0 (6.2)
Height in cm	27.8 (1.2)	27.6 (1.1)	28.5 (1.7)	27.8 (3.5)
Weight in kg	68.5(6.2)	71.0(7.6)	76.0(8.9)	72.1(7.9)
Years in current category	2.0 (3.0)	3.0 (4.4)	1.5 (1.8)	2.0 (3.4)
Years at or above category 3	7.0 (5.0)	7.0 (4.9)	1.5 (2.0)	3.5 (4.6)
Total years in competitive cycling, categories 1-5	8.5 (6.0)	11.0 (4.8)	5.3 (2.9)	6.5 (4.8)

Note: Median values with standard deviations in parentheses.

Table 2

Participant's Training Data

	Category 1	Category 2	Category 3	Total Group
Number of days riding per week	7	6	6	6
Miles per week km per week	350.0 (99.5) 563.2(160.1)	262.5 (66.0) 422.4 (106.2)	212.5 (50.4) 341.9 (81.1)	250 (92.2) 402.3 (148.3)
Number of hours riding per week	20 (6.3)	13.75 (3.5)	14.5 (3.0)	15.0 (4.8)
Percentage monitoring heart rate	88%	71%	81%	79%
Percentage monitoring cadence	75%	57%	56%	61%
Percentage monitoring power	38%	29%	6%	21%

Note: Median values with standard deviations in parentheses.

55% for category 1 (n=8) and category 3 (n=16) riders, and a 68% median score for category 2 (n=13) riders.

Nutrition understanding and knowledge scores were examined using the years of experience grouping. Cyclists with less than 6 years of competitive experience had a median score of 11 correct answers. Cyclists with 6 to 11 years of competitive experience had a median score of 14 correct, and cyclists with greater than 11 years of experience had a median score of 15 correct answers. The median percentage score for each years of experience grouping was 50% cyclists with less than 6 years, 64% for cyclists between 6 and 11 years, and 68% for cyclists with over 11 years of competitive experience.

A Kruskal-Wallis test indicated that no statistically significant differences in medians were present among cyclists in category 1, 2 or 3 ($p = 0.204$). The null hypothesis that there would be no statistically significant differences in the median level of nutrition understanding and knowledge was not rejected. Due to the small sample size, power was .32, making it difficult to detect differences between racing categories even though the effect size was .60. Practical significance was assessed using Eta squared, which equaled .081.

Using the years of experience in competitive cycling grouping, a Kruskal-Wallis test indicated that no statistically significant differences in nutrition understanding and knowledge were present among cyclists with 0 to 6, 6 to 11 and 11 or more years of competitive cycling experience ($p = 0.063$). The effect size was .81, indicating a greater distance between the mean scores by years of experience groupings than by racing category (effect size .60).

Although Kruskal-Wallis tests found no statistically significant differences between the median scores of category 1, 2, and 3 cyclists, a strong pattern of increasing scores was found when examined by years of competitive cycling experience. The newest cyclists, with less than 6 years of experience had a median score of 50%. As experience increased, nutritional understanding and knowledge increased. Table 3 summarizes median scores and median percentage scores on the nutrition understanding and knowledge survey by racing category and by years of experience groupings.

Sources of Nutrition Information

The relationship between racing category and the top (1st) choice source of nutrition information was investigated. A moderate correlation was observed between racing category and the top choice for nutrition information, Cramer's V was 0.296.

Upon review of the top three sources of nutrition information cyclists rely on, magazines, teammates, and websites were utilized to the greatest extent in all three racing categories. In category 1 riders, 38% chose magazines and 25% chose college nutrition/health classes as the first choice of nutrition information. The highest percentage of category 2 riders (36 %) selected "other" as their first choice, while 21% choose magazines as their first choice for nutrition information. Among category 3 riders, 25% selected magazines, 19% teammates and 19% "other" as the primary source they rely on for nutrition information. It is interesting to note that a single category 1 and a single category 3 rider selected the coach as their first source of nutrition information.

Table 3

Summary of Scores on Nutrition Understanding and Knowledge Survey

Scores by Category	Category 1 n=8	Category 2 n=13	Category 3 n=16
Median number of correct answers	12 (4.4)	15 (3.4)	12 (2.4)
Median proportion score	55%	68%	55%
Scores by Years of Experience	**≤ 6 years n=17**	**6-11 years n=10**	**≥ 11 years n=10**
Median number of correct answers	11 (2.9)	14 (3.3)	15 (3.5)
Median proportion score	50%	64%	68%

Note: Median values with standard deviations in parentheses. Total number of questions=22.

Sports nutritionist was selected 13% by category 1, 7% by category 2, and 6% by category 3 riders as their number one source. A registered dietician was selected 13% by category 1 riders, and not selected by category 2 and 3 riders.

Second ranked choices for nutrition information included teammates (25%, 21%, 19%) and magazines (38%, 14%, 31%) in category 1, 2, and 3 riders, academic journals in category 1 only (25%), and the coach in category 2 only (21%). Sports nutritionist and registered dietician were not selected as a second choice source.

Third ranked nutrition information sources included teammates in category 2 (38%) and category 3 (19%) riders, websites for category 1, 2, and 3 (25%, 14% and 44%) riders and the coach at 38% for category 3 riders. Sports nutritionist was not selected as a third choice, and registered dietician was selected by a single category 2 rider as a source of nutrition information. Table 4 contains the 1st choice for nutrition information percentages for participants by racing category and the percentages of respondents who identified the nutrition information source as a 1st, 2nd, or 3rd choice. The relationship between racing category and level (low, medium, and high) of nutrition information source was moderate, with category 1 riders selecting a high level source of nutrition information 57% of the time (1st choice) and not utilizing the low level sources as 1st choice options. Category 2 and category 3 riders chose a high-level nutrition information source 39% and 17% respectively. Category 2 and 3 riders utilized all three levels as first choices for nutrition information. Table 5 summarizes this information. Years of experience grouping and level (low, medium, and high) of nutrition information source were cross tabulated. Cyclists with 11 or more year of experience selected a high

Table 4

Percentage of Participants Utilizing Various Nutrition Information Sources

Source	Category 1		Category 2		Category 3	
	1st Choice	Selected	1st Choice	Selected	1st Choice	Selected
Sports Nutritionist	13%	13%	8%	21%	6%	13%
Academic Journals	-	38%	14%	29%	-	13%
Teammates	-	38%	-	57%	19%	56%
Web Sites	-	25%	-	21%	6%	56%
Family	-	-	-	-	13%	25%
Coach	13%	50%	-	21%	6%	19%
Magazines	38%	75%	21%	50%	25%	63%
Nutrition/Health Classes	25%	38%	7%	7%	6%	13%
Registered Dietician	13%	13%	-	7%	-	-
Other	-	-	36%	43%	19%	25%

Note: The heading "selected" indicates respondents who choose the source as a 1st, 2nd or 3rd choice

Table 5

First Choice Nutrition Information Sources by Racing Category

Source	Category 1	Category 2	Category 3
High Level	57%	39%	17%
-Sports Nutritionist -Registered Dietician -College Nutrition/Health classes -Academic Journals			
Medium Level -Websites -Coach -Magazines	43%	23%	39%
Low Level -Teammates -Family -Other	-	39%	44%

level source of nutrition information 50% of the time (1st choice) while the remainder of the group selected the high-level nutrition sources less frequently. Table 6 summarizes the years of experience grouping and level of nutrition information source data.

Nutrition Understanding and Knowledge Questions

Upon examining the questions that were most frequently missed, four specific areas of knowledge and understanding were identified as weak. These suggest potential topics for nutrition education in elite, competitive cyclists.

The first area of concern was hydration: specifically, how much fluid to consume during training, why hydration is important, and how to monitor hydration status. A total of 26% of the group correctly answered the question dealing with how much fluid to consume while training. Over half (53%) of the cyclists selected the wrong answer when determining why hydration is important, and 50% missed the question dealing with how to monitor hydration status.

Questions relating to nutrition practices that are optimal for training and recovery were missed by the majority of the group. Question # 6, addressing "recovery and training" was missed by 58% of the group. The correct response, "recovery and training are primarily enhanced by replacing fluid losses and increasing carbohydrate intake", was primarily chosen when combined with distractor "b" that referred to "increasing protein intake to 30% of total calories".

A difference between categories emerged on the question that addressed how much carbohydrate is needed 4 hours before a race to maximize glycogen storage, with more category 3 riders missing the question (50%), and category 1 and 2 riders answering

Table 6

First Choice Nutrition Information Sources by Years of Experience Groupings

Source	≤6 years	6-11 years	≥ 11years
High Level -Sports Nutritionist -Registered Dietician -College Nutrition/Health classes -Academic Journals	33%	17%	50%
Medium Level -Websites -Coach -Magazines	77%	8%	15%
Low Level -Teammates -Family -Other	31%	46%	23%

incorrectly 38% and 31% respectively. Another question dealing with post event carbohydrate replacement was missed by 78% of the group, when asked about the use of high and low glycemic index foods. This question was difficult because the terminology (glycemic index) would most likely be familiar if the cyclist had worked with a sports nutritionist or registered dietician, but not as familiar if the cyclist relied on media or teammates for information. The glycemic index ranks carbohydrate foods by how fast they enter the blood stream. Many cyclists use carbohydrate gels, these gels are comprised of simple sugars with a high glycemic index for quick energy before and during a race. Another question relating to carbohydrates and training was missed 62% of the time. The question asked about the ideal percentage of calories from carbohydrates in an energy replacement beverage and provided three distractors, 3-4% carbohydrate and 10-15% carbohydrate, and isotonic glucose. The correct answer, 5-8% carbohydrate, is optimal for absorption of fluid and carbohydrates without the gastro-intestinal side effects of more concentrated drinks.

An additional area of concern was the lack of understanding in regards to percentages of macronutrients (protein, carbohydrate, and fat) in a rider's daily caloric intake. An overwhelming 80% of the group missed the question on what percentage of one's daily caloric intake should come from fats. The distractors most frequently selected placed fat intake at 5-15% of total daily calories, which represents a prudent diet for someone who has a high risk for or known coronary artery disease, but not for an elite endurance athlete. The correct answer "d", 20-25% of total daily calories from fats, was selected by 18% of the group. Combined with 64% of the cyclists incorrectly identifying the percentage of protein needed in an endurance athlete's diet, macronutrient needs appear to be misunderstood in this group. The most frequently selected distractor for the protein needs question was "b", 30-35% of daily caloric intake from protein. The correct answer, "a" was 10-15% of daily caloric intake from protein for endurance athletes.

The areas of nutrition understanding and knowledge where the cyclists scored relatively well included balanced diet/number of servings, optimal protein sources, recognition of complex carbohydrates in foods, and identifying nutritional needs that are increased when training increases. Category 1 and category 3 cyclists missed the question pertaining to dietary manipulation to promote body fat loss (63% and 56% respectively), yet category 2 riders missed the same question only 21% of the time.

<u>Summary</u>

This chapter reviews the item analysis and reliability of the survey instrument. Demographic and training data is reported by measures of central tendency and variability (Tables 1 & 2). Nutrition survey scores are examined by racing category and years of experience groupings (Table 3). Nutrition information sources are summarized as the percentage selected as first choice and percentage selected as a 1st, 2nd, or 3rd choice for category 1, 2, or 3 riders (Table 4). Additionally, 1st choice nutrition sources selected by category 1, 2, and 3 riders are examined by high, medium and low-level information sources for usage patterns (Table 5). Lastly, the nutrition understanding and knowledge questions are examined for frequently missed questions as well as questions most participants answered correctly.

CHAPTER V

Discussion

This section discusses the outcomes of the study and how the information can be utilized to benefit competitive cyclists. Sources of nutrition information utilized by competitive cyclists and specific areas of the nutrition understanding and knowledge survey are reviewed. Nutrition topics identified by the questions most frequently missed will be examined as potential areas for nutrition education and intervention in elite, competitive cyclists. Recommendations are given, to increase nutrition understanding and knowledge in cyclists. The use of the Internet in this research is examined, identifying the positive and negative elements pertaining to participant recruitment, survey distribution, and communication with the population sampled. Lastly, recommendations for future research are included in this chapter.

The nutrition understanding and knowledge survey asked respondents to rank order the top three sources of information relied upon regarding nutrition. For the entire group, magazines (61%), teammates (53%), and web sites (37%) were utilized to the greatest extent, while nutrition professionals (sports nutritionists and registered dieticians) were selected 8% of the time. The coach and the category "other" were selected as a source of nutrition information 26% of the time

Burke et al. (1991) examined running and triathlon magazines, finding the nutrition articles to be based on current, scientific research and offer practical guidance for improving the dietary habits of endurance athletes. Bicycle magazine, a world-wide publication for cyclists that claims to have the largest subscription base of any cycling magazine, features nutrition articles written by Dr. Susan Barr, a sports nutrition expert and road cyclist. Despite the existence of sound nutritional information in magazines, two concerns should be considered. The first concern is whether cyclists relying on magazines as their primary source of nutrition information have the skills necessary to implement the dietary recommendations. A second concern is the plethora of magazine advertisements selling ergogenic aids and supplements using testimonials from world-class cyclists and other sponsored athletes. Not only do the ads outnumber the nutrition articles, the simplicity of buying a new beverage or taking a pill to improve performance can be very enticing.

Teammates constitute a logical source of nutrition information, based on proximity and rapport. Road cyclists train together, often putting in hours of low intensity base training, with plenty of time to discuss dietary practices and compare results. Combined with travel time to races, down time between events at races, and team meetings, many opportunities to trade personal experiences with dietary changes, ergogenic aids, and supplements exist, yet based on the low nutrition and understanding scores found by this study, teammates do not appear to be the best source for nutrition information.

Web sites offer a convenient way to find nutrition information for all athletes, including cyclists. Although scientific, detailed web sites are available, they are outnumbered by web sites selling ergogenic aids for cyclists. Performing an Internet search under "cycling and nutrition" produced two excellent sites, Cycling Performance

Tips (www.halcyon.com) and nutrition information at Bicycle Source (www.bicyclesource.com/body/nutrition). The same search produced over 25 sites that sold products to improve cycling performance.

The minimal use of nutrition professionals as a source of information is of concern. Category 1, which includes professional cyclists, reported the highest use of nutrition professionals, possibly due to the presence of a team nutritionist. Although sport specific nutrition counseling will incur a cost to the athlete, the benefits are well documented (ADA/ACSM, 2000). The category "other" as a source of nutrition information was selected 13 times as a 1st, 2nd, or 3rd choice. Six of the respondents that chose "other" specified "books" on the available space for a write-in information source and three listed an actual title and author, The Cyclist's Training Bible by Joe Friel. This book is directed at experienced, competitive cyclists, and offers 194 pages of training information followed by a short, 15 page chapter titled "Fuel" that addresses nutritional needs of the competitive cyclist. Friel advocates a diet based on Paleolithic man's diet, composed of 33% or more protein, 20-25% fat, and less than 50% carbohydrates (Friel, 1996). Scientific studies evaluating the Paleolithic diet are not referenced. Friel does not discuss how to determine daily caloric needs, making the percentages of macronutrients irrelevant. If a cyclist is consuming 3000 kcal per day, with 45% carbohydrate, he will consume 338 g of carbohydrate, which is below the 500-600 g of carbohydrate needed per day to maximize glycogen storage. However, if the cyclist's calorie intake is 5000 kcal per day, at 45% carbohydrate, he would consume 563 g of carbohydrate as recommended by the ADA/ACSM position stand (2000). The protein recommendation of 33% or more of total calories is most likely not desirable, as the athlete consuming 5000 calories per day would need to eat 413g of protein a day, or 59 oz of fish, chicken or meat, which equals four chicken breasts and six cans of tuna. Included in the "Fuel" chapter of Friel's book is a list of ergogenic aids that are beneficial to endurance athletes: branched-chained amino acids, medium-chain trigylcerides, creatine monohydrate, sodium phosphate, and glycerol. Academic journal references are provided for each ergogenic aid (Friel, 1996); however, the disadvantages are not reported, and it appears that research findings are unequivocal.

Participants in this study had a median score of 55%, which suggests a low level of nutrition understanding and knowledge among elite, competitive cyclists. Based on the questions most frequently missed, hydration, nutrition for training and recovery, pre and post competition carbohydrate intake, and macronutrient percentages of daily caloric intake were identified as potential topics for nutrition education and intervention.

Proper hydration practices are crucial, to achieve optimal performance and reduce the risk of an elevated core body temperature, a life-threatening situation (ADA/ACSM, 2000). This study identified a lack of understanding of why hydration is important, with over half of the respondents failing to identify "increased core body temperature" as the most serious potential health effect caused by insufficient fluid intake. Increased knowledge of proper hydration before, during, and after exercise, combined with how to monitor hydration is recommended for this group.

The majority of the participant group missed questions related to recovery and training, selecting the distractor that suggested increasing protein intake to 30% of total caloric intake. Research has shown that long duration endurance exercise training will increase oxidation of amino acids, and it has been recommended that endurance athletes consume 1.2-1.4 g of protein per kg of body weight per day (ADA/ACSM, 2000; Lemon, 1997). However, recovery is primarily enhanced by replenishing glycogen stores in the liver and muscle, and replacing fluid losses, especially in cyclists who train intensely multiple days per week (ADA/ACSM, 2000)

Pre and post competition carbohydrate intake is another area where nutrition knowledge can benefit elite cyclists who compete in stage races taking place over several consecutive days. The recommendation to consume high glycemic index carbohydrate sources immediately after competition to promote maximal glycogen synthesis rates prior to the subsequent day of racing (ADA/ACSM, 2000) was not familiar, as 78% of respondents answered incorrectly.

The most misunderstood area of nutrition in this group was the distribution of total calories between fats, proteins, and carbohydrates. Nutrition professionals readily work with percentages to calculate the optimal mix for a balanced diet. The ADA/ACSM Nutrition and Athletic Performance report (2000) states that research data does not indicate a need for a substantially different diet for athletes than what is recommended for the average American. That statement seems impossible. When elite athletes are training daily at a high intensity, it seems logical that they need more nutrients. This is where the percentages have meaning to the athlete, based on total calorie needs. To insure optimal performance energy intake must equal energy expenditure in endurance athletes (ADA/ACSM, 2000), and elite, competitive cyclists incur extremely high, energy expenditures training and racing (van Erp-Baart et al., 1989). An example illustrates this concept; a 72 kg elite male cyclist needs 5,000 calories per day to meet total energy expenditure. It is recommended that endurance athletes consume 1.2-1.4 g of protein per kg of body weight (ADA/ACSM, 2000; Lemon, 1997), which equals 86-101 g of protein per day. Upon calculating his dietary percentages at 25% fat, 15% protein, and 60% carbohydrates, he needs to consume 139 g of fat, 750 g of carbohydrates, and 188g of protein. Since 1.2-1.4 g of protein per kg of body weight represents 86-101 g of protein, 188 g (15%) is well above (87-102 g) the protein recommendation (ADA/ACSM, 2000; Lemon, 1997). The additional protein calories (348-408 calories) are a surplus, and could be consumed as fat (39-45 g) or carbohydrate (87-102 g) intake. By consuming the extra calories from fat or carbohydrate, an additional energy source for endurance exercise is provided.

Dietary fat intake for endurance athletes should comprise 20-25% of total daily calories, providing essential fats, fat-soluble vitamins (antioxidants), and an additional source of energy calories (ADA/ACSM, 2000). A majority of the respondents (80%) selected 5-10% or 10-15% of calories from fat, demonstrating that athletes have adopted the belief that an extremely low fat diet is ideal for endurance sports. This misconception is hazardous to elite cyclists as it could lead to an inability to meet dietary energy needs (total calories), resulting in protein calories being used for energy. Evidence that higher amounts of dietary fats can be beneficial exists, especially in endurance athletes with extremely high daily energy needs. The fear that higher levels of dietary fat will alter plasma lipid profiles and body fat levels is addressed by Brown and Cox, who found no change in either parameter (1998). This finding is beneficial to athletes with very high-energy expenditures. By increasing the percentage of calories from fats, total energy calorie needs can be met without sacrificing protein calories for energy.

Based on the nutrition understanding and knowledge scores found in this study, nutrition intervention and counseling is recommended. In a paper addressing sports nutrition counseling, Clark (1999) points out that excellent training and coaching is wasted if the athlete has depleted glycogen stores, runs out of energy, or becomes dehydrated during a race. Additional recommendations by Clark include the need to protect athletes from nutritional misconceptions among peers and coaches, marketing campaigns for supplements and ergogenic aids, and their own unsubstantiated beliefs about dietary practices and performance. The position of this paper is that nutrition intervention for elite, competitive cyclists should include an assessment of energy expenditure and energy intake; determination of protein needs relative to body weight; knowledge of carbohydrate needs to maximize glycogen synthesis; understanding of the importance of hydration; knowledge of optimal fluid intake prior, during, and after training or racing; and the components of a balanced diet to achieve optimal macronutrient intake. To accomplish the above listed goals for nutrition intervention, a sports nutritionist should be enlisted, along with individual counseling combined with workshops that teach athletes the skills needed to assess energy needs and dietary intake are recommended. Delivery of nutrition information is important, building links from understanding of nutrition concepts to practical skills, such as using a food diary to record intake and estimating serving sizes to quantify intake. This paper proposes utilizing the USDA Food Guide Pyramid and adapting the number of servings to accommodate the increased caloric needs of endurance athletes.

Use of the Internet

Internet usage continues to grow exponentially, since its' introduction in 1987 (www.pbs.org, 2001). With almost half of the United States population (135 million people) using e-mail to communicate, e-mail messages equal the number of phone messages in an individual's daily communications (www.iconocast.com, 2001). Utilization of the Internet was crucial to the recruitment of category 1, 2, and 3 cyclists to participate in this study. By using e-mail addresses to contact cycling organizations, road racing teams, coaches, race directors, and cycling clubs all over the United States the distribution of the "call for research participants" letter was increased dramatically. The "call for research participants" letter could be printed out and posted in a facility, distributed at a team meeting, or forwarded to a team or club e-mail list serve. Individuals interested in participating were able to contact the researcher by e-mail to ask questions about the study and/or request a survey. Potential participants used e-mail to inquire about the goals of the research and ask questions of the researcher. Cyclists who chose to participate used email to comment on the survey, make suggestions, request the answers to the survey questions, and express interest in the results of the study. Participants frequently suggested the survey "be made available as a web page, to increase the likelihood of cyclists choosing to participate." It was expressed that it would be "faster and more convenient to complete the survey online and not have to print and fax or mail it back." Two participants offered to "develop the web site in exchange for nutrition counseling" after taking the survey and feeling "unsure of what I know" about nutrition and cycling performance. An additional benefit of the Internet in this research was the opportunity for respondents to express their interest in nutrition understanding. Several of the participant's expressed their interest in increasing nutritional knowledge and understanding, by emailing comments such as "please grade my survey and tell me which questions I missed, I want to know if I am on the right track" and "can I get the answers to the survey so I can improve?"

A few negative experiences occurred with the use of the Internet. One participant was very suspicious of the "Call for Research Participants" letter, stating he thought it was "an advertisement (spam) designed to get information from him." Another cyclist asked in an e-mail, "Are you connected with The Zone diet program?" and was concerned he was being subjected to an indirect "sales pitch." Additionally, it is unknown how many cyclists actually read the e-mail containing the "Call for Research Participants" letter and how many deleted it. It was suggested by several participants that the researcher post information about the study on a web page, since "lots of people won't open e-mail sent to them by an unfamiliar source due to a prevalence of viruses."

Future Research Recommendations

The nutrition understanding and knowledge survey created for this study was found to have a reliability of 0.66. It is recommended that this study be used as a pilot, and the weak survey items revised. To increase sample size, recruitment of participants could take place in the winter during the off-season for competitive road racing. Many professional and amateur category 1 cyclists travel during the season, decreasing the availability of participants during data collection for this research. Based on the findings of this study, a nutrition intervention study using elite cyclists is warranted. It is recommended that female cyclists be recruited as participants for nutrition intervention and counseling research. To increase the effectiveness of nutrition counseling, interviews of both male and female participants are suggested to examine psychosocial influences on eating behaviors and attitudes towards nutrition.

Summary

It is not enough to provide athletes with nutrition information in the form of articles or books. To maximize the benefits of nutrition, athletes should hone their nutritional skills, learning to assess caloric expenditure and evaluating dietary intake for total calories, adequate protein, and a wide variety of foods to insure adequate micronutrient intake. Hydration knowledge must be enhanced to decrease the risk of dehydration and increase performance with optimal hydration practices. By increasing understanding of high and low glycemic index foods, athletes will understand pre and post competition carbohydrate replacement practices to maximize glycogen synthesis. The best way to accomplish the above goals is for cyclists to work with a nutrition professional in some capacity. This study determines that category 1, 2, and 3 cyclists could increase their nutrition understanding and knowledge, thus d nutrition intervention and counseling would be beneficial.

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APPENDIX A. Call for Participants Letter

Dear cyclist or cycling coach,

My name is Leslie Funk, I am a graduate researcher at San Jose State University and I am recruiting category 1, 2 or 3 cyclists interested in participating in a research study. The study investigates nutritional understanding and knowledge among elite, competitive cyclists. Participation involves completing a questionnaire, asking about sources used for nutrition information and questions that examine the participants' current understanding of nutrition for endurance sports, specifically cycling. Additional data is collected on demographics, competition and training in order to describe the participants in this study.

The results of this study may contribute to future research in the area of nutrition for endurance athletes and increase the understanding of current nutrition knowledge in elite cyclists.

To participate, please email or call me to request survey(s).

funkenterprises@msn.com

(408) 923-0407

Please provide your mailing address, and the number of surveys you need. I will mail you the surveys, as well as self addressed, stamped envelopes in which to return the completed surveys. The survey is also available as an email attachment, as a pdf file. The pdf format requires Acrobat Reader for printing. Instructions on how to return the survey (by fax or by mail) are included.

If you have any questions, I would be happy to answer, please call or email me.

Sincerely,

Leslie S. Funk, Graduate Researcher, San Jose State University

APPENDIX B. Letter of Informed Consent

San Jose State University
Department of Human Performance

Dear participant,

My name is Leslie Funk and I am a graduate researcher at San Jose State University. I am currently looking for cyclists competing in category 1, 2 or 3 to participate in a project regarding sport nutrition for endurance athletes. The primary objective of this study is to investigate the level of nutritional understanding and knowledge among elite, competitive cyclists. Aspects of particular interest to this project include information sources, familiarity with nutrition principles and factors that influence performance in endurance sports. This letter serves as an informed consent, after reading it, your decision to complete and return the survey indicates you have given your informed consent for participating in this study.

To study the aspects of sport nutrition listed above, the attached survey has been developed. Please complete and return this survey. Your contribution is important and will be very much appreciated! Upon request, the results of this study will be made available to you.

In accordance with guidelines regarding research with human subjects (a) your participation is voluntary and no risks to you through participation are expected, (b) nothing adverse results from a decision not to participate, and (c) all responses will be recorded anonymously. Confidentiality of all participants will be maintained, and any identifying information, such as addresses, emails or fax numbers will be destroyed upon completion of this research. The potential benefit of this study to participants and other competitive cyclists is increased information regarding nutritional understanding and knowledge and competitive ranking of elite cyclists. If a significant difference in nutritional knowledge and understanding exists between cyclists of different categories, additional research involving nutrition education and intervention may be warranted.

If you have questions about this research project please contact Leslie Funk, at (408) 923-0407, or by email at funkenterprises@msn.com. Any complaints regarding this project may be directed to Dr. Greg Payne, Chair of the Human Performance Department, at (408) 924-3010. Any questions about your rights as a participant may be directed to Dr. Nabil Ibrahim, Associated Vice President for Graduate Studies and Research at (408) 924-2480.
Sincerely,

Leslie S. Funk
Graduate researcher, San Jose State University

APPENDIX C. Nutrition Survey Instrument

Note: The actual survey instrument was two pages in length, with questions on the front and back of each page.

Nutrition Survey

Please complete this survey regarding your familiarity with the nutritional needs of competitive cyclists

Nutrition Information:

Please rank order (1=1st choice) the top 3 sources of information you rely on regarding nutrition.

___	Sports Nutritionist	___	Coach
___	Academic Journals	___	Magazines
___	Teammates	___	College nutrition/health courses
___	Web sites	___	Registered Dietician
___	Family	___	Other ______________________

To respond to this section, place the letter of your choice in the space provided.

1. ___ What foods would be included in the **least** number of servings per day for endurance athletes interested in eating a well balanced diet?
   a. fruits and fruit juices
   b. dairy products. meats. eggs
   c. fats. oils, sweets
   d. rice. cereals. pastas

2. ___ Endurance athletes should drink water during exercise in order to
   a. increase aerobic metabolism
   b. limit sodium lost in sweat production
   c. maintain hydration status
   d. all of the above

3. ___ An endurance athlete's protein needs are determined by:
   a. the intake of nutrients
   b. nothing specific. it is best to consume as much as possible
   c. the type of sport and amount of training done
   d. a and c

4. ___ Assuming an endurance athlete is well hydrated before exercise. during exercise fluid consumption should be
   a. 8-12oz every 30 minutes
   b. 16oz or more every 30 minutes
   c. 5-10oz every 15-20 minutes
   d. 3-5 oz every 5 minutes for the first hour of exercise

5. ___ The vitamin and mineral needs of endurance athletes are best met by
   a. using high potency multi-vitamin & mineral supplements
   b. adhering to a balanced diet
   c. eating plenty of foods high in fiber
   d. adhering to a diet primarily comprised of dairy, vegetables, and fruits

6. ___ After high intensity training or competition, recovery is primarily enhanced
   a. by replacing fluid losses
   b. by increasing protein intake to 30% of total calories
   c. by increasing carbohydrate intake
   d. a and c
   e. all of the above

7. ___ If insufficient fluid is ingested during exercise, which of the following potential health effects is the most serious?
   a. increased core body temperature
   b. hyponatremia (sodium depletion)
   c. heat cramps
   d. impaired muscular function

8. ___ To preserve stored carbohydrates in the body (glycogen), endurance athletes should
   a. consume carbohydrates during training or competition lasting 3 or more hours
   b. consume carbohydrates during training or competition lasting 1 or more hours
   c. consume increased protein during the meal 3-4 hours prior to training or competition
   d. b and c

9. ___ When body fat loss is desired, endurance athletes should:
   a) decrease calories by decreasing intake from all food groups
   b) decrease fat intake to 10% of daily caloric intake
   c) decrease carbohydrate intake to 40% of total daily caloric intake
   d) utilize supplements that increase resting metabolic rate

10. ___ With respect to protein intake among endurance athletes,
   a. a powder protein supplement is best
   b. foods high in protein should be avoided since they are also high in fat
   c. supplements are important, protein needs cannot be met with a regular diet
   d. a balanced diet with adequate calories provides all the protein that is needed

11. ___ When endurance athletes are dehydrated
   a. they may feel overly tired after they exercise
   b. their muscular strength during exercise may be diminished
   c. their endurance during exercise may be diminished
   d. all of the above

12. ___ The majority of an endurance athlete's carbohydrate intake should be
   a. complex carbohydrates
   b. simple sugars
   c. fiber
   d. saturated sugars

13. ___ The following contain primarily complex carbohydrates
    a. raw vegetables and fruits
    b. whole grains. beans, potatoes
    c. organic juices or smoothies
    d. carbohydrate replacement beverages

14. ___ Hydration status can be monitored
    a) by how much sweat an athlete produces during exercise
    b) by the amount and color of the athlete's urine
    c) by weighing the athlete before and after exercise
    d) a combination of b and c
    e) all of the above

15. ___ For endurance athletes. calories from fats should be approximately
    a. 5% - 10% of their daily caloric intake
    b. 10% - 15% of their daily caloric intake
    c. 20% - 25% of their daily caloric intake
    d. 30% of their daily caloric intake

16. ___ To meet nutritional needs, endurance athletes should consume approximately
    a. 15,000 calories a day
    b. 3,500 calories a day
    c. 1,500 calories a day
    d. depends on gender, sport, and training program
    e. none of the above

17. ___ What foods would be included in the **greatest** number of servings per day for endurance athletes interested in eating well?
    a. milk, yogurt, cheese
    b. meat, eggs, seafood
    c. apples, bananas, grapes
    d. rice, cereal, pasta

18. ___ As training volume and intensity increases, an athlete primarily needs more calories and
    a. additional vitamins and minerals for optimal performance
    b. additional proteins for optimal performance
    c. additional fats for optimal performance
    d. additional carbohydrates for optimal performance

19. ___ For endurance athletes, calories from proteins should be approximately
    a. 10% - 15% of their daily caloric intake
    b. 30% - 35% of their daily caloric intake
    c. 40% - 60% of their daily caloric intake
    d. 75% - 80% of their daily caloric intake

20. ___ For endurance athletes, calories from carbohydrates should be approximately
    a. 15% - 20% of their daily caloric intake
    b. 25% - 30% of their daily caloric intake
    c. 55% - 65% of their daily caloric intake
    d. 75% - 80% of their daily caloric intake

21. ___ A carbohydrate replacement beverage is ideally composed of
    a. isotonic glucose
    b. 3-4% carbohydrate
    c. 10-15% carbohydrate
    d. 5-8% carbohydrate

22. ___ When a pre-competition meal is consumed 4 hours before a race, to maximize stored carbohydrates in the body (glycogen) the meal should
    a. contain 150-300g of carbohydrates (600-1200 calories)
    b. contain 25-75 g of carbohydrates (100-300 calories)
    c. contain equal amounts of protein and carbohydrates (600-1200 calories total)
    d. contain a supplement that provides the RDA for vitamins and minerals

23. ___ When estimating your caloric expenditure on a moderate intensity (65% of VO_2 max), two hour training ride, you should consider
    a. your dietary intake over the last 8 hours
    b. your maximal oxygen consumption (VO_2 max)
    c. your body weight
    d. b & c
    e. all of the above

24. ___ After completing day 1 of a 2-day stage race, carbohydrate stores in the body (glycogen) are best replenished by
    a. consuming carbohydrate containing foods with a low glycemic index
    b. consuming a mixed meal, containing carbohydrates, proteins and mono-saturated fats
    c. consuming energy bars that contain chromium, magnesium, iron and zinc
    d. consuming carbohydrate containing foods with a high gylcemic index

25. ___ The specific nutrition goals for cyclists include
    a. energy intake equal to energy expenditure and optimal hydration
    b. minimize fat intake, balance protein and carbohydrate intake
    c. adequate carbohydrate intake to maintain glycogen stores
    d. a and c
    e. all of the above

To respond to the items below write the information requested in the space provided.

Demographics:

___ Age ___ Height ___ Weight ___ Gender

Competition:

___ Bike racing category ___ Years in this category

___ Number of years racing at or above category 3

___ Number of years (total in all categories, including novice) engaged in competitive cycling.

Training:

____ Number of days you ride per week.

_____ Total training mileage per week.

_____ Number of hours you ride per week.

What parameters do you monitor while training? (check all that apply)

_____ Heart rate _____ cadence _____ power (watts)

Upon completion of this survey please fax it,
Attention: Leslie Funk, Human Performance, SJSU
FAX NUMBER: 408-924-3053

or mail it to:
San Jose State University, Human Performance Dept.
Attention: Leslie Funk
One Washington Square
San Jose, CA. 95192-0054

San José State
UNIVERSITY

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APPENDIX D. Institutional Review Board Approval Letter

To: Leslie S. Funk
15208 Rosemar Avenue
San Jose, CA 95127-3656

From: Nabil Ibrahim, N. Ibr
AVP, Graduate Studies & Research

Date: April 2, 2001

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

> "Level of Nutritional Understanding and Knowledge Among Elite, Competitive, Male Cyclists."

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Nabil Ibrahim, Ph.D., immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information. This approval is in effect for one-year and data collection beyond April 2, 2002 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at
(408) 924-2480.